HAZUS-MH: Earthquake Event Report

Region Name: ***Southern California***

Earthquake Scenario: ***2008 Shake Out***

Print Date: ***April 09, 2007***

Disclaimer:

The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

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General Description of the Region

HAZUS is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of HAZUS is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 10 counties from the following state:

California

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 57,094.46 square miles and contains 4,277 census tracts. There are over 6,818,000 households in the region and has a total population of 20,637,512 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 5,378,000 buildings in the region with a total building replacement value (excluding contents) of $1,374,639,000,000. Approximately 98.00 % of the buildings (and 0.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be $96,052,000,000 and $25,561,000,000, respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 5,378,000 buildings in the region which have an aggregate total replacement value of $1,374,639,000,000. Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 90% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

HAZUS breaks critical facilities into two (2) groups: essential facilities and high potential loss (HPL) facilities. Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 257 hospitals in the region with a total bed capacity of 54,260 beds. There are 6,689 schools, 281 fire stations, 474 police stations and 23 emergency operation facilities. With respect to HPL facilities, there are 362 dams identified within the region. Of these, 217 of the dams are classified as 'high hazard'. The inventory also includes 2,954 hazardous material sites and 2 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 2 and 3.

The total value of the lifeline inventory is over 121,613,000,000. This inventory includes over 15,383 kilometers of highways, 9,616 bridges, and 453,253 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	9,616	24,623.90
	Segments	1,453	54,442.40
	Tunnels	22	38.10
		Subtotal	**79,104.40**
Railways	Bridges	263	48.20
	Facilities	155	398.70
	Segments	2,540	4,691.40
	Tunnels	0	0.00
		Subtotal	**5,138.30**
Light Rail	Bridges	51	13.30
	Facilities	0	0.00
	Segments	14	209.20
	Tunnels	0	0.00
		Subtotal	**222.50**
Bus	Facilities	123	69.50
		Subtotal	**158.20**
Ferry	Facilities	0	0.00
		Subtotal	**0.00**
Port	Facilities	235	604.50
		Subtotal	**604.50**
Airport	Facilities	312	1,363.30
	Runways	258	9,462.00
		Subtotal	**10,825.30**
		Total	**96,053.20**

Table 3: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	4,292.50
	Facilities	52	2,043.20
	Pipelines	0	0.00
		Subtotal	**6,335.70**
Waste Water	Distribution Lines	NA	2,755.50
	Facilities	110	8,644.80
	Pipelines	0	0.00
		Subtotal	**11,400.30**
Natural Gas	Distribution Lines	NA	1,837.00
	Facilities	14	18.00
	Pipelines	0	0.00
		Subtotal	**1,855.00**
Oil Systems	Facilities	67	63.50
	Pipelines	0	0.00
		Subtotal	**63.50**
Electrical Power	Facilities	114	14,797.20
		Subtotal	**14,797.20**
Communication	Facilities	435	51.30
		Subtotal	**51.30**
		Total	**34,439.50**

Earthquake Scenario

HAZUS uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

Scenario Name	2008 Shake Out
Type of Earthquake	User-defined
Fault Name	NA
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	NA
Latitude of Epicenter	NA
Earthquake Magnitude	7.80
Depth (Km)	NA
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	NA

Building Damage

Building Damage

HAZUS estimates that about 165,954 buildings will be at least moderately damaged. This is over 3.00 % of the total number of buildings in the region. There are an estimated 18,671 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 4 below summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries the expected damage by general building type.

Table 4: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	660	0.0	28	0.01	15	0.01	5	0.02	2	0.01
Commercial	65,869	1.38	5,744	1.34	3,015	2.60	1,030	3.16	410	2.20
Education	431	0.01	25	0.01	10	0.01	3	0.01	0	0.00
Government	1,464	0.03	109	0.03	65	0.06	25	0.08	11	0.06
Industrial	10,657	0.22	1,228	0.29	730	0.63	226	0.69	56	0.30
Other Residential	409,108	8.55	54,153	12.65	47,053	40.55	28,837	88.41	17,942	96.1
Religion	2,395	0.05	199	0.05	103	0.09	38	0.12	14	0.07
Single Family	4,295,313	89.75	366,554	85.64	65,055	56.06	2,453	7.52	236	1.26
Total	**4,785,897**		**428,040**		**116,046**		**32,617**		**18,671**	

Table 5: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	4,449,177	84.32	375,941	87.82	65,258	56.91	1,799	5.52	80	0.43
Steel	28,972	0.55	3,228	0.75	2,240	1.95	859	2.63	265	1.41
Concrete	30,261	0.57	2,549	0.60	1,140	0.99	405	1.24	202	1.08
Precast	15,543	0.29	1,426	0.33	647	0.56	202	0.62	70	0.37
RM	79,463	1.51	3,488	0.81	2,308	2.01	1,103	3.38	333	1.78
URM	9,845	0.19	1,008	0.24	331	0.29	128	0.39	102	0.55
MH	663,251	12.57	40,398	9.44	42,739	37.27	28,121	86.22	17,620	94.36
Total	**5,276,512**		**428,038**		**114,663**		**32,617**		**18,672**	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 54,260 hospital beds available for use. On the day of the earthquake, the model estimates that only 52,696 hospital beds (97.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 100.00% of the beds will be back in service. By 30 days, 100.00% will be operational.

Table 6: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	257	0	0	254
Schools	6,689	0	0	6,398
EOCs	23	1	0	21
PoliceStations	474	2	0	435
FireStations	281	4	0	258

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

System	Component	Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	1,453	0	0	1,453	1,453
	Bridges	9,616	239	21	9,283	9,410
	Tunnels	22	0	0	22	22
Railways	Segments	2,540	0	0	2,540	2,540
	Bridges	263	4	0	259	262
	Tunnels	0	0	0	0	0
	Facilities	155	4	0	155	155
Light Rail	Segments	14	0	0	14	14
	Bridges	51	0	0	51	51
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	123	2	0	123	123
Ferry	Facilities	0	0	0	0	0
Port	Facilities	235	0	0	235	235
Airport	Facilities	312	3	0	212	212
	Runways	258	0	0	258	258

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 8-10 provide information on the damage to the utility lifeline systems. Table 8 provides damage to the utility system facilities. Table 9 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis. Table 10 provides a summary of the system performance information.

Table 8 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	52	4	0	48	52
Waste Water	110	8	0	99	110
Natural Gas	14	0	0	14	14
Oil Systems	67	0	0	67	67
Electrical Power	114	3	0	104	114
Communication	435	47	0	423	435

Table 9 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	229,627	38,276	9,570
Waste Water	137,777	30,274	7,569
Natural Gas	91,852	32,361	8,091
Oil	0	0	0

Table 10: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	6,819,181	1,593,365	1,556,943	1,494,920	1,133,432	184,250
Electric Power		88,287	51,469	19,281	3,389	129

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 123 ignitions that will burn about 1.79 sq. mi 0.02 % of the region's total area.) The model also estimates that the fires will displace about 5,579 people and burn about $351,000,000 of building value.

Debris Generation

HAZUS estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 5.00 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 39.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 221,920 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Social Impact

Shelter Requirement

HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates (8,516 households to be displaced due to the earthquake. Of these, 2,517 people (out of a total population of 20,637,512 will seek temporary shelter in public shelters.

Casualties

HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 11 provides a summary of the casualties estimated for this earthquake

Table 11: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	66	17	3	5
	Commuting	1	1	3	0
	Educational	0	0	0	0
	Hotels	60	15	2	5
	Industrial	92	21	3	6
	Other-Residential	3,881	858	79	143
	Single Family	1,132	93	6	12
	Total	**5,323**	**1,005**	**96**	**171**
2 PM	Commercial	4,766	1,215	187	366
	Commuting	8	12	20	4
	Educational	1,395	376	61	119
	Hotels	11	3	0	1
	Industrial	681	158	22	42
	Other-Residential	931	209	20	35
	Single Family	236	20	1	3
	Total	**8,028**	**1,993**	**311**	**570**
5 PM	Commercial	4,183	1,084	170	324
	Commuting	235	319	531	103
	Educational	151	40	7	12
	Hotels	17	5	1	1
	Industrial	426	99	8	26
	Other-Residential	1,413	313	29	53
	Single Family	419	35	3	5
	Total	**6,844**	**1,895**	**749**	**524**

Economic Loss

The total economic loss estimated for the earthquake is $18,526,350,000, which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were $16,534,430,000; 12 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 60 % of the total loss. Table 12 below provides a summary of the losses associated with the building damage.

Table 12: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Loses							
	Wage	0.00	32.15	612.31	29.01	15.81	689.28
	Capital-Related	0.00	14.03	509.01	17.81	4.53	545.38
	Rental	85.08	156.72	235.76	10.54	6.35	494.45
	Relocation	8.60	6.20	14.38	0.93	2.31	32.42
	Subtotal	**93.68**	**209.10**	**1,371.46**	**58.29**	**29.00**	**1,761.53**
Capital Stock Loses							
	Structural	599.50	480.29	633.67	146.39	68.81	1,286.01
	Non_Structural	3,865.67	2,358.51	2,159.12	530.15	230.50	5,549.34
	Content	1,497.03	567.20	1067.45	341.10	115.52	2,014.28
	Inventory	0.00	0.00	37.87	69.44	1.84	55.94
	Subtotal	**5962.20**	**3,406.00**	**3,898.11**	**1,087.08**	**416.67**	**14,770.06**
	Total	**6,055.88**	**3615.10**	**5,269.57**	**1,145.37**	**445.67**	**16,531.59**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages. Tables 13 & 14 provide a detailed breakdown in the expected lifeline losses.

HAZUS estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 15 presents the results of the region for the given earthquake.

Table 13: Transportation System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	54,442.47	$0.00	0.00
	Bridges	24,623.71	$336.44	1.37
	Tunnels	38.02	$0.25	0.66
	Subtotal	**79,104.20**	**336.69**	
Railways	Segments	3,691.35	$0.00	0.00
	Bridges	48.19	$0.48	1.00
	Tunnels	0.00	$0.00	0.00
	Facilities	398.72	$25.99	6.52
	Subtotal	**4138.26**	**26.47**	
Light Rail	Segments	209.22	$0.00	0.00
	Bridges	13.27	$0.01	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**222.49**	**0.01**	
Bus	Facilities	158.20	$12.11	7.65
	Subtotal	**158.20**	**12.11**	
Ferry	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Port	Facilities	604.51	$24.68	4.08
	Subtotal	**604.51**	**24.68**	
Airport	Facilities	1,363.37	$103.88	7.61
	Runways	9,461.99	$0.00	0.00
	Subtotal	**10,825.36**	**103.88**	
	Total	**95,060.02**	**503.84**	

Table 14: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	2,043.20	$113.08	5.53
	Distribution	4,592.50	$172.24	3.75
	Subtotal	**6,635.70**	**$285.32**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	8,644.80	$368.69	4.26
	Distribution	2,755.50	$136.23	4.94
	Subtotal	**11,400.30**	**$504.92**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	18.00	$0.31	1.72
	Distribution	1,837.00	$145.62	7.93
	Subtotal	**1,855.00**	**$145.93**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	7.90	$0.21	2.65
	Subtotal	**7.90**	**$0.21**	
Electrical Power	Facilities	14,797.20	$549.59	3.71
	Subtotal	**14,797.20**	**$549.59**	
Communication	Facilities	51.30	$2.63	5.13
	Subtotal	**51.30**	**$2.63**	
	Total	**34,747.40**	**$1,488.60**	

Table 15. Indirect Economic Impact with outside aid
(Employment as # of people and Income in millions of $)

	LOSS	Total	%
First Year			
	Employment Impact	7,002,240	115.92
	Income Impact	25,067	7.07
Second Year			
	Employment Impact	2,962,688	49.03
	Income Impact	13,183	4.23
Third Year			
	Employment Impact	71,475	1.18
	Income Impact	3,411	1.09
Fourth Year			
	Employment Impact	4,026	0.07
	Income Impact	(300)	-0.10
Fifth Year			
	Employment Impact	230	0.01
	Income Impact	(509)	-0.16
Years 6 to 15			
	Employment Impact	8	0.00
	Income Impact	(521)	-0.16

Appendix A: County Listing for the Region

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Imperial, CA

Kern, CA

Los Angeles, CA

Orange, CA

Riverside, CA

San Bernardino, CA

San Diego, CA

San Luis Obispo, CA

Santa Barbara, CA

Ventura, CA

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
California					
	Imperial	142,361	4,686	735	5,421
	Kern	661,645	30,346	4,462	34,809
	Los Angeles	9,519,338	487,927	128,148	616,075
	Orange	2,846,289	172,147	45,066	217,214
	Riverside	1,545,387	82,594	13,208	95,802
	San Bernardino	1,709,434	85,804	14,541	100,345
	San Diego	2,813,833	167,455	34,078	201,533
	San Luis Obispo	246,681	15,823	2,705	18,528
	Santa Barbara	399,347	23,777	4,667	28,444
	Ventura	753,197	47,179	9,385	56,565
Total State		**20,637,512**	**1,117,738**	**256995**	**1,374,736**
Total Region		**20,637,512**	**1,117,738**	**256995**	**1,374,736**